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09/485,657	03/24/2000	LEONARD COLIN ANDREWS	89073	2124

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EXAMINER	
MICHALSKI, JUSTIN I	

ART UNIT	PAPER NUMBER
2644	

DATE MAILED: 06/03/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Interview Summary	Application No.	Applicant(s)	
	09/485,657	ANDREWS, LEONARD COLIN	
	Examiner	Art Unit	
	Justin Michalski	2644	

All participants (applicant, applicant's representative, PTO personnel):

(1) *Justin Michalski*. (3)_____.

(2) *F. William McLaughlin*. (4)_____.

Date of Interview: *27 May 2005*.

Type: a)☒ Telephonic b)☐ Video Conference
c)☐ Personal [copy given to: 1)☐ applicant 2)☐ applicant's representative]

Exhibit shown or demonstration conducted: d)☐ Yes e)☒ No.
If Yes, brief description: _____.

Claim(s) discussed: _____.

Identification of prior art discussed: _____.

Agreement with respect to the claims f)☐ was reached. g)☒ was not reached. h)☐ N/A.

Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: *Attorney of record faxed attched document "Non-Data Applications for Category 5 Cable" indicating the section starting at the bottom of page 10 regarding power. The Office disagreed and indicated that Cat-5 cables are known to conduct power*.

(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims allowable, if available, must be attached. Also, where no copy of the amendments that would render the claims allowable is available, a summary thereof must be attached.)

THE FORMAL WRITTEN REPLY TO THE LAST OFFICE ACTION MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW. (See MPEP Section 713.04). If a reply to the last Office action has already been filed, APPLICANT IS GIVEN ONE MONTH FROM THIS INTERVIEW DATE, OR THE MAILING DATE OF THIS INTERVIEW SUMMARY FORM, WHICHEVER IS LATER, TO FILE A STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. See Summary of Record of Interview requirements on reverse side or on attached sheet.

SINH TRAN
SUPERVISORY PATENT EXAMINER

Examiner Note: You must sign this form unless it is an Attachment to a signed Office action.

_____
Examiner's signature, if required

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)
In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

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FAX COVER SHEET

DATE: May 25, 2005

ATTENTION: Examiner Justin I. Michalski

FROM: F. William McLaughlin

FAX NO.: 571-273-7524

RE: Andrews Serial No. 09/485,657

PAGES TRANSMITTED: 12 +This Transmittal Page Only

ADDITIONAL MESSAGE:

Justin:

Per our discussion, see the attached article "Non-Data Applications for Category 5 Cable", particularly starting at the bottom of page 10.

Bill

IF YOU HAVE ANY DIFFICULTY RECEIVING THIS TRANSMISSION, PLEASE CONTACT Corinne Byk AT (312) 876-1800.

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Technical Papers

Non-Data Applications for Category 5 Cable

Most of this paper was originally presented as "Multimedia with MediaTwist" at Belden "Tech Day",
September 28, 1999

Steve Lampen
Technology Specialist
Multimedia Products
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What is Multimedia?
For UTP cable products, "multimedia" is the ability of a cable to support data and non-data applications. Data applications might include 10baseT or 100baseT networking, emerging Gigabit systems, such as Gigabit Ethernet™ or Wideband™ .

Non-data applications encompass a wide variety of signal types such as analog audio, in both consumer and professional applications or Video, both analog and digital, and running in applications as diverse as surveillance, factory automation, and professional SDI digital video.

Almost anything done by twisted pairs or coax cables, with bandwidth below approximately 500 MHz is possible. This would therefore include applications such as machine control (RS-422, or RS-485), or even the bandwidth "king" broadband/CATV

Networking Options
All of these signal types listed above could easily be configured within a network architecture. There are many software packages that allow you to ship audio and video, for instance, as a part of the network data stream. Videoconferencing to the desktop is most often distributed in this fashion. A small video picture of low quality covers a small portion of the user screen. The bandwidth used for the distribution is directly related to the frame rate, the detail, and the size of the image. Often a picture can be displayed for a bandwidth "cost" of only a few kilobits.

Since these network applications are software-driven, cable choice only applies to the network as a whole. And, while we do not intend to discuss these software applications, it should be noted that any application that requires added bandwidth should obviously employ the cable with the widest bandwidth and which provides the greatest possible distance.

What is Shared Sheath?
It's one thing to carry an exotic non-data signal on a UTP cable. But what about using all four pairs of a UTP to handle multiple different signals?

The ability to support more than one signal type on a single 4-pair is termed "shared sheath". It should be mentioned at the outset that shared-sheath applications are mentioned in TIA/EIA 568A but only in regards to multiple data signals on multipair cable, such as

25-pair Category 5. No mention is made of combining non-data applications.

What can be combined in shared sheath? The answer to this question lies squarely in the performance of a UTP cable. Each non-data application has "critical" factors. In multichannel audio, for instance, crosstalk and capacitance are the critical issues. It is then the most critical parameter of the most critical signal that rules over all. This parameter will set things like the "maximum distance" the cable can run.

Some of the shared sheath combinations might include data + data, such as two 10baseT or two 100baseT circuits, data + audio, data + video, multiple audio channels, multiple video channels, audio + video, data + machine control. With each of these combinations, an analysis of the various signals must be made and the requirements of each ascertained.

What Cables?

We are specifically talking about UTP Category cables, including Category 5, and "Enhanced" Category cables, such as Category 5E, and Category "6". There is also data available in the Anixter "Levels" program that may apply to non-data applications. This would include Anixter Level 6 and Level 7 cables. However, in the interest of simplicity, we will concentrate on Category 5 (Belden 7811A), 5e (Belden 1583A and 1700A), and 6 (Belden 1872A).

Plenum versions of the last three cables are also available. Performance of plenum versions, and suitability for non-data applications, is the same as the non-plenum versions mentioned in this paper.

It should be noted that, as of this writing, Category 6 specifications are still not ratified. It is therefore more appropriate to use the performance figures of the actual cable than the standards as outlined in TIA/EIA-568-A and similar documents. Where standards do exist they may be appropriate to judge the performance of "generic" cable for data and non-data applications, but the actual measured performance of a cable will always give more accurate comparisons.

All cables are compared at a distance of 100 meters (328 ft.) Studies done in 1982 by AT&T indicate that this distance covers 99.9% of all network office installations. It is not too hard to imagine, therefore, than the same distance would be appropriate for most non-data installations. One exception to this might be factory automation and control.

Unbalanced Analog Audio Requirements

Unbalanced audio is the "standard" for consumer audio interconnection. Since Category products are now commonly used in the wiring of new houses, and home communication upgrades, it is essential that we include it here. However, these cables have no standards, just "common" standards...

Parameter	7811A	Unbalanced analog
Crosstalk	-102 dB @ 20 kHz	-90 dB @ 20 kHz
Impedance	100Ω ± 15Ω	No requirements
Capacitance	15 pF/ft	<50 pF/ft.
Gage	24 AWG	No requirements

Format	Balanced	Unbalanced
Distance	100 meters (328 ft.)	20-30 ft. maximum

Since this is an unbalanced standard, in order to employ UTP, or any twisted pairs, a balun must be used. The choice of baluns is covered in a later section.

Balanced Analog Audio Requirements
Balanced analog audio cables are stranded twisted pairs of 22AWG or 24AWG, with a foil shield and drain wire, and covered with an overall jacket. They are commonly used in professional installations such as radio or television stations, or recording studios.

Parameter	7811A	1583A/1700A	1872A	Balanced Audio
Crosstalk at 20 kHz	-102 dB	-105 dB	Unreadable >110 dB	used to be -60 dB now, it's -90 dB
Noise (S/N) at 20 kHz	-102 dB	-105 dB	Unreadable >110 dB	used to be -60 dB now, it's -90 dB
Impedance	100Ω ± 15Ω	100Ω ± 12Ω	100Ω ± 12Ω	No requirements
Capacitance	15 pF/ft	15 pF/ft	15 pF/ft	30 – 50 pF/ft.
Gage	24 AWG	24 AWG	24 AWG	22 AWG/24 AWG
Format	Balanced	Balanced	Balanced	Balanced
Conductor	Solid	Solid	Solid	Stranded
Construction	UTP	UTP	UTP	Foil shield

Another View of UTP and Balanced Lines
One manufacturer, Radio Systems (Dan Braverman, Michael Sirkis), has brought out a series of products called "Studio Hub". These are balanced line analog audio patch panels which use Category 5 as the wiring medium. However, they suggest shielded Category 5 (STP). The decision to use STP rather than UTP was based on the requirement for good common mode noise rejection (CMRR). The following quote is from an email of Mr. Sirkis:

> "Radio Systems has no control over what signals will be connected to Studio Hub. This means balanced or unbalanced (although we say StudioHub is a balanced product someone will either hook up an unbalanced piece of equipment or unknowingly create an unbalanced connection), and any signal level from mic to line. We also have no control on what signals maybe adjacent to Studio Hub cables.
>
> In addition, most broadcast equipment is designed with active differential inputs that are constructed with 1% resistors. There is no trimming provided for CMRR. Hence, 40 dB CMRR is often the case (or worse if all the resistor values go to the wrong side of the tolerance). Sometimes, station engineers will build circuits with what ever parts are available -- 5% resistors (now its 26 dB CMRR).
>
> While there is some tolerance (from the user) for cross talk between left and right channels (of the same source) there is no tolerance for cross talk between dissimilar signals. Since we can't count on the rejection of common mode

signals, or masking them with level the best thing to do about crosstalk is to minimize it from happening. Hence, shielded cable."

Also, during initial development of StudioHub not a single customer was willing to consider StudioHub with UTP. Without STP there would have been very little (if any) StudioHub sold.

The lessons here are obvious. For any data or non-data application, the performance of the cable is only as good as the boxes to which it is attached. You can ruin excellent cable performance with poor equipment choices.

However, this problem is not insurmountable if one chooses to determine the CMRR figures of equipment before it is purchased. Most modern analog equipment provides excellent performance values.

Stop Thinking in a "Shielded World"

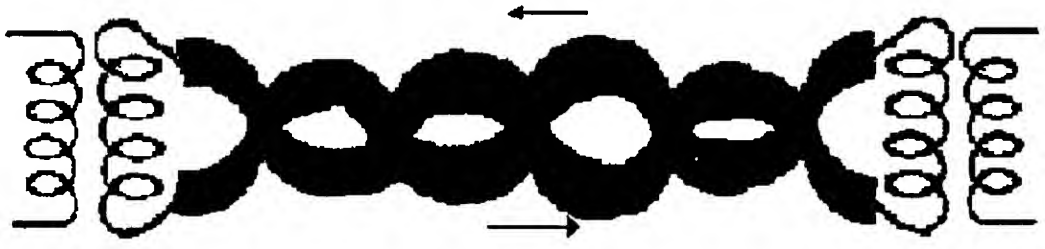
It is fully understood that many engineers, especially those in broadcast, were raised in a "shielded pair" world, and the idea of using UTP requires a philosophical jump. But isn't that why you're reading this paper? You want to be given all the options before you decide how to wire up an installation. UTP is definitely one of those options!

Note: For UTP to be effective in most audio systems, the radiating signal must be extremely low and the CMRR high. This requires the source differential output to be equal and opposite (equal symmetry). In addition, the destination differential amplifier must have excellent CMRR. This is not commonplace in today's environment and therefore careful consideration must be used in designing such a system. The effects of low frequency shielding and coupling can not simply be ignored without the proper considerations.

There are many other benefits to UTP, such as no ground loops (no shield, no drain wire) which would be attractive to designers of non-data systems.

What is a Balanced Line?

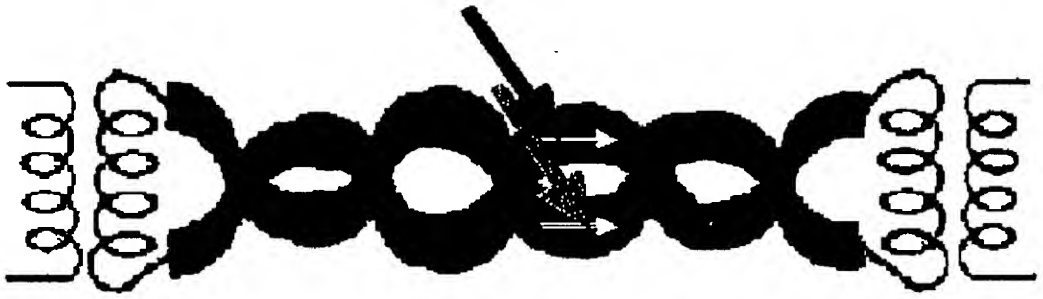
A balanced line is a wiring configuration that uses two wires to transfer the signal from point to point. The key is that the signal is the same on both wires, but opposite polarity (see arrows). Thus, if you add up the signal at any given place along the pair, the sum total should always be zero.



Signals travel in opposite direction or "differential mode".

When noise strikes the pair, it induces a voltage in the same ("common mode ") direction. At either end of the cable is a transformer or active balanced circuit (and electronic

equivalent to a transformer). Since this will only pass signals that are of opposite polarity ("differential mode"), the noise, which is the same, cancels out.



Noise travels in the same direction or "common mode"

The construction of the cable and the "balance" of the system at either end are critical for good noise rejection. In multipair cables, this is also the basis for low crosstalk. Here is a list of factors that will compromise low noise and low crosstalk performance:

1. The conductors are not the same size (AWG) or same resistance. ("Resistance unbalance")
2. The conductors are not the same length. ("Resistance unbalance")
3. The conductors are not in the center of their insulation. ("Capacitance unbalance")
4. The conductors vary in distance between them ("Capacitance unbalance")
5. The different pair twistings are not ideal.
6. Bending the cable forces pairs together ("nesting") which dramatically increases crosstalk.
7. Bending the cable makes pairs separate, changing the impedance of that pair, making them radiate signal energy.

Here's why fixing these problems leads to lower crosstalk and lower noise ingress/egress:

The closer the wires are to each other, the more identical the noise is on both wires and the more completely it cancels out.

There is currently no computer on earth that could cost-effectively determine the most effective twist ratios between four pairs at 100 MHz (much less 350 MHz or 550 MHz).

Dramatically different twist ratios can give you excellent crosstalk numbers. But the length of the wires is also radically different, affecting skew/delay, the timing of the four pairs. Skew/delay is critical in systems that use all four pairs simultaneously such as Gigabit network protocols or RGBS video transmission.

Separating the pairs physically dramatically improves crosstalk. But the construction must keep the pairs separated, especially when the cable is flexed or bent.

Digital Audio Requirements

Digital audio is a sampled version of analog audio. Desired quality is achieved by choosing different sampling rates. The higher the sampling rate, the better the copy will be at the end of the process. Here are the sampling rates and bandwidths:

Sampling Rate	Multiply by...	Bandwidth	Application
32 kHz	128	4.096 MHz	Voice/News
38 kHz	128	4.864 MHz	DAT
44.1 kHz	128	5.6448 MHz	Home CD
48 kHz	128	6.144 MHz	Audio w/Video
96 kHz	128	12.288 MHz	Recording
192 kHz	128	24.576 MHz	Recording

In any system with multiple bandwidths, "If it works with the highest, it will work with them all." So, we compare AES/EBU digital audio requirements at 25 MHz, the highest bandwidth.

On the next page, we compare digital audio with standard Category 5. This is such a good fit, that many people are surprised. They shouldn't be! Digital audio is really just another type of data stream, a rather generic one at that, built to run down high quality twisted pairs.

Parameter	7811A	AES/EBU Digital Audio
Crosstalk	-41 dB @ 25 MHz	-30 dB @ 25 MHz
Impedance	100Ω ± 15Ω	110Ω ± 20% (88-132Ω)
Capacitance	15 pF/ft	13 pF/ft.
Gage	24 AWG	22/24 AWG, no spec
Format	Balanced	Balanced
Conductor	Solid	Stranded
Construction	UTP	Shielded

All UTP constructions do well with AES/EBU digital.

Parameter	7811A	1583A/1700A	1872A	AES/EBU Audio
Crosstalk @ 25 MHz	-41 dB	-44.3 dB	-51.3 dB	-30 dB
Impedance	100Ω ± 15Ω	100Ω ± 12Ω	100Ω ± 12Ω	110Ω ± 20%
Capacitance	15 pF/ft	15 pF/ft	15 pF/ft	13 pF/ft
Gage	24 AWG	24 AWG	24 AWG	22/24 AWG
Format	Balanced	Balanced	Balanced	Balanced
Conductor	Solid	Solid	Solid	Stranded
Construction	UTP	UTP	UTP	Foil shield

There are three standards for AES/EBU. The first is the balanced line, outlined above. The other two are based on coax cable. There is a professional version (AES-3id) and a consumer version (S/PDIF). They are not identical and not completely compatible. To use twisted pairs in the coax version, a balun would be required to convert from 110Ω twisted pairs to 75Ω coax.

Video Requirements

Parameter	7811A	1583A/1700A	1872A	Standard

				analog video
Bandwidth	100 MHz	200 MHz	350 MHz	DC to 4.2 MHz
Crosstalk	-53 dB @ 4 MHz	-56 dB @ 4 MHz	-63 dB @ 4 MHZ	-60 dB (no spec)
Impedance	100Ω ± 15Ω	100Ω ± 12Ω	100Ω ± 12Ω	75Ω ± 3Ω
Capacitance	15 pf/ft	15 pf/ft	15 pf/ft	20 pF/ft.
Gage	24 AWG	24 AWG	24 AWG	Varies with cable size
Format	Balanced	Balanced	Balanced	Unbalanced

Since standard video cable is "unbalanced" coax, it is not directly compatible with any twisted pair or UTP format. To use UTP, we must convert from BALanced to UNbalanced. The device is therefore called a BALUN. (That's "bal-un", not "bay-lun"). Baluns are sometimes called "matching transformers" or "impedance converters."

Digital Video

Digital video comes in a number of data rates. Here are some of the uncompressed professional video formats:

Data Rate	Bandwidth	Protocol
143 Mbps	71.5 MHz	NTSC composite
177 Mbps	88.5 MHz	PAL composite
270 Mbps	135 MHz	NTSC/PAL component

All of these appear in the standard SMPTE 259M. The most common is the 270-Megabit standard, and therefore all cable and system testing are done to that standard. It should be noted that 135 MHz is beyond the 100 MHz limit for standard Category 5. Therefore, this cable is eliminated from running these signals and Category 5e or 6 cables are then required.

Significant live testing was done with 270/135 at UL Labs. Both bonded-pair Belden products (1700A, 1872A) passed the Class A -- Digital Devices spec for digital coax to the home. These are the first, and so far only, twisted pair cables to have passed this test.

Below are the comparisons between SMPTE 259M SDI (serial digital interface) and Category 5e and Category 6. It is obvious that a balun will be required to match the impedance and to convert from balanced to unbalanced (and back again).

Parameter	7811A	1583A/1700A	1872A	SMPTE 259M
Bandwidth	100 MHz	200 MHz	200 MHz	135 MHz
Crosstalk @ 135 MHz	Unknown	>33 dB	>40 dB	-30 dB
Impedance	100Ω ± 15Ω	100Ω ± 12Ω	100Ω ± 12Ω	75Ω ± 3
Capacitance	15 pF/ft	15 pF/ft	15 pF/ft	16 pF/ft
Gage	24 AWG	24 AWG	24 AWG	Coax - various
Format	Balanced	Balanced	Balanced	Unbalanced

Conductor	Solid	Solid	Solid	Solid center
Construction	UTP	UTP	UTP	Coax
Distance	Not Useable	328 ft.	450 ft.	>659 ft.

It should be noted that coax cable would go significantly farther than UTP, based on superior impedance tolerance and lower resistance (more copper).

Machine Control Requirements

Machine control systems are basically low data rate networks for controlling devices. In the broadcast world, they are commonly used to control audio and video tape machines, cart playback devices, or hard disc servers, which mimic tape machines.

Hard-disc servers are becoming the *de facto* standard to replace audio and video tape machines and are the first widely accepted amalgam of data and audio/video technology. So audio, video, and control signals to this equipment could employ the same cable. The table below compares Category 5 to the three common forms of machine control.

Parameter	7811A	RS-232	RS-422	RS-485
Bandwidth	100 MHz	Unspecified	10 MHz	10 MHz
Crosstalk	47 dB @ 10 MHz	Unspecified	Unspecified	Unspecified
Impedance	100Ω ± 15Ω	Unspecified	100Ω	120Ω
Capacitance	15 pF/ft	30 pF/ft	12.5 pF/ft	12.5 pF/ft
Gage	24 AWG	Unspecified	24 AWG	24 AWG
Format	Balanced	*Unbalanced**	Balanced	Balanced
Construction	UTP	Stranded	Stranded	Stranded

*We are unaware of any baluns made to convert RS-232 to UTP.

Broadband/CATV Requirements

The hardest of all non-data applications for UTP is broadband/CATV because of one single factor, bandwidth. Cable TV systems often go up to 1 GHz (158 channels) or more. There are even 500-channel systems currently being offered.

Since Category 5 is only specified to 100 MHz (and even MediaTwist is only spec'd to 550 MHz), these UTP cables offer insufficient parameters to carry the full spectrum of broadband/CATV signals. Does this mean you can't use UTP for broadband/CATV? No. It just means you will be bandwidth (channel) limited.

There are many applications, such as schools, hotels and hospitals, where only a few channels are offered. In those applications, UTP might be a possible choice.

The other limitation to UTP is gage size. Two 24 AWG wires do not come close to a broadband/CATV cable in terms of basic resistance. Therefore, UTP is significantly limited in distance compared to standard coax designs.

And finally, we have cost. Broadband/CATV coax is very cost-effective. Its cost is probably closer to Cat 5 than any other application we have mentioned so far.

Therefore, UTP really offers only one thing which coax cannot: versatility. Installed in a

hotel, for instance, UTP can deliver any one of a dozen types of signals. It can be 100baseT for one customer, deliver video for the next, be an Internet access port the next day, all while running automated devices in the room.

Many of these applications can be running on different pairs inside the same cable, "shared sheath", which we touch on below. This table is the comparison with broadband /CATV:

Parameter	7811A	1583A/1700A	1872A	CATV (RG-6)
Attenuation	22 dB @100 MHz	32 dB @200 MHz	40 dB @350 MHz	12 dB @350 MHz
Bandwidth	100 MHz	200 MHz	350 MHz	1 GHz+
Equiv. Channel	Channel 6	Channel 22	Channel 45	Channel 158+
Impedance	100Ω ± 15Ω	100Ω ± 12Ω	100Ω ± 12Ω	75Ω
Capacitance	15 pF/ft	15 pF/ft	15 pF/ft	Unspecified
Gage	24 AWG	24 AWG	24 AWG	Different/CCS
Format	Balanced	Balanced	Balanced	Unbalanced
Conductor	Solid	Solid	Solid	Solid CCS
Construction	UTP	UTP	UTP	Coax

Since broadband/CATV is an unbalanced system a balun is required to run those signals on UTP. It should be noted that not only the cable, but also the balun will be required to handle an extremely wide bandwidth since even standard CATV goes up to 1 GHz . With Belden MediaTwist, we give some specs out to 550 MHz, equivalent to Cable Channel 78. The widest bandwidth balun available is the ETS PV-884, which is specified out to 850 MHz. (Channel 121.)

Comparison of Attenuation between UTP and broadband/CATV RG-6 at 100 meters

Cable	50 MHz	100 MHz	200 MHz	350 MHz
RG-6	4.66 dB		9.16 dB	11.9 dB
Category 5	16 dB	22 dB	No data to compare	
Category 5e	15.8 dB	21.7 dB	32 dB	No data
Category 6	15.5 dB	19.9 dB	29.1 dB	40 dB

As you can see, there's really no comparison. UTP cannot go as far as coax, cannot handle as broad a bandwidth as coax. The key advantage to UTP is versatility. Broadband/CATV coax will only be that: coax into your television. It will never connect to your phone, or run an automated factory, or even carry audio. But multimedia cables, such as MediaTwist, can easily do that and more.

Shared Sheath Requirements

Shared sheath systems are driven by the "critical signal". This is often the cable with the highest frequency, or possibly the widest bandwidth. The pair with that signal will be the controlling factor for the entire cable.

Since the parameters for all different signals are so varied, it is virtually impossible to predict how multiple signals will interact. But the chart below is a starting point:

Shared-Sheath Critical Parameters
A = attenuation
B = bandwidth
C = capacitance
I = impedance/impedance tolerance
X = crosstalk

	Unbalanced Audio	Balanced Audio	Digital audio	Standard Video	Digital SDI Video	RS-422	RS-485	10baseT	100baseT
Unbalanced Audio	C,X	C, X	X	A,I	B, A, I	X, C	X	X	X
Balanced Audio	C,X	C, X	X	A,I	B, A, I	X, C	X	X	X
Digital audio	X	X	A, I	X	B,A, I	I	I	I	X, I
Standard Video	A, I	A, I	X	A, I	B, A, I	A, I	A, I	A, I, X	A, I, X
Digital SDI Video	B, A, I	B, A, I	B, A. I	B,A,I	B, A, I	B, A, I	B, A, I	B, A, I	B, A, I, X
RS-422	X, C	X, C	I	A, I	B, A, I	X	X	X	X
RS-485	X	X	I	A, I	B, A, I	X	X	X	X
10baseT	X	X	I	A, I, X	B, A, I	X	X	X	X
100baseT	X	X	X, I	A, I, X	B, A, I, X	X	X	X	X

You will note that crosstalk is by far the most common critical factor. As frequencies go higher, impedance, bandwidth and attenuation come into play. Capacitance is a critical factor only with audio, but because Category cables are so good, with such low capacitance, capacitance becomes a non-issue with most other signal types.

And, if you intend to do some shared sheath applications, here's where you can start. Fill in the blanks below with the parameters for the signals you intend to feed down the pairs. You have two blanks below, but that could be duplicated to give you four. We have inserted Category 5 specifications, but if you use cable which is 5e or 6, make your own chart and start with those!

Parameter	Category 5
Crosstalk	@ MHz
Impedance	100Ω ± 15Ω
Capacitance	15 pF/ft
Gage	24 AWG
Format	Balanced

Where Shared Sheath Fails
Shared-sheath applications fail where UTP itself fails. The limitations are based on the

resistance of 24 AWG pairs..This is obviously why these cables cannot be used for power conductors or speaker cables. These and other similar applications require low resistance.

The second limitation is bandwidth. Where low-loss at high frequencies are required, coaxial cable is still the "king". But UTP, especially enhanced UTP is encroaching on this realm of "coax" and is getting closer all the time. This is one of the reasons that uncompressed broadcast quality HDTV signals are not even mentioned. They run at a bandwidth of 750 MHz, for which no data is available on any UTP. And, even if the UTP were perfect, the 24 AWG resistance would limit HDTV signals to about 90 feet.

Are we done playing with twisted pairs? Absolutely not! Maybe the "next" super UTP will be able to carry broadband/CATV to 500 channels, or uncompressed HDTV, or microwave signals!

If our investigation into twisted pairs has proven anything, it is that this transmission medium is far from dead!

Other New Systems

There are new networking systems emerging such IEEE 1394 "Firewire™ ". This is a hot-swap "hubless" network scheme mainly for consumers, but it may have limited professional applications as well. While the standard cable looks nothing like Category 5, the IEEE Committee is currently considering Category 5 as an alternate wiring method.

Since the cable carries signals and power, the limitation to distance is based on resistance of 24 AWG UTP. Even then, it is felt that the distance currently specified between devices (4.5m, or 15 ft.) could be increased up to (45m or 150 ft.) with Category 5. The trick may be to double-up the conductors used to carry power, thus cutting the resistance in half.

So What Do I Need to Run...

Application	Balun?	ETS Part #	Comments
10baseT	No		
100baseT	No		
Gigabit Ethernet™	No		No shared sheath
Wideband™	No		No shared sheath
Analog Consumer Audio	Yes	PA-800 series	
Analog Balanced Audio	No		Forced balancing option
Digital Audio (balanced)	No		Forced balancing option
Digital Audio (coax)	Yes	PA-810 series	XLR to BNC
Analog video	Yes	PV-860 series	Bandwidth 4.5 MHz
Analog video	Yes	PV-840	Bandwidth 60 MHz
RGB-S	Yes	PV-890 series	BNC or HD-9
S-Video* plus stereo audio	Yes	PV-902	consumer unbalanced
Audio + Video (baseband)	Yes	PV-900	consumer = RCA jacks
Digital video	Yes	PV-850	(270Mbps/135 MHz)
Broadband/CATV	Yes	PV-882 series	Cable Channel 77
Broadband/CATV	Yes	PV-884 series	Cable Channel 121

* Also known as Y/C or S-VHS™. VHS is a trademark of JVC. Ethernet is a trademark of Xerox Corp. Wideband is a trademark of Wideband Corp.

Thanks to ETS (Energy Transformation Systems) for their work on UTP baluns. They can be reached at www.etslan.com, 1-800-752-8208

And it's not just ETS...
There are many other balun manufacturers. Many of them can be found on Belden's web page in the white paper "Video and UTP". You can find it at www.belden.com/Video and UTP.pdf.

We're Interested Too!
Are you planning an installation of UTP for a non-data application not mentioned in this paper? The author would be very interested in talking to you. If you have any questions or comments on the contents of this paper, contact the author at Steve.Lampen@belden.com.